SeaQuest NM3 Beam Cherenkov Proposal

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Abstract

Experiment E906, SeaQuest, is requesting to place a Beam Cherenkov in the NM3 enclosure. This instrumentation device will be used to provide a bucket by bucket beam signal for analysis. The signal will be used for multiple purposes such as triggering dead time, DAQ live time, and basic proton normalization.

Location

SeaQuest requests that there are two prerequisites to install the Cherenkov. The first geographical constraint is that the location needs to be relatively close to the E906 target and detector apparatus. Second the ideal location must be easily accessible in case of mirror replacement.

NM3 could be broken down into two sections the upstream section and the downstream section. The transition between those two sections is a beam pipe flange that reduces from four feet to four inches in diameter. This flange is approximately 100 feet upstream of the target table. In Figure 1 is the flange installed in NM3. This location would be ideal for the constraints and operational considerations needed for the Beam Cherenkov.
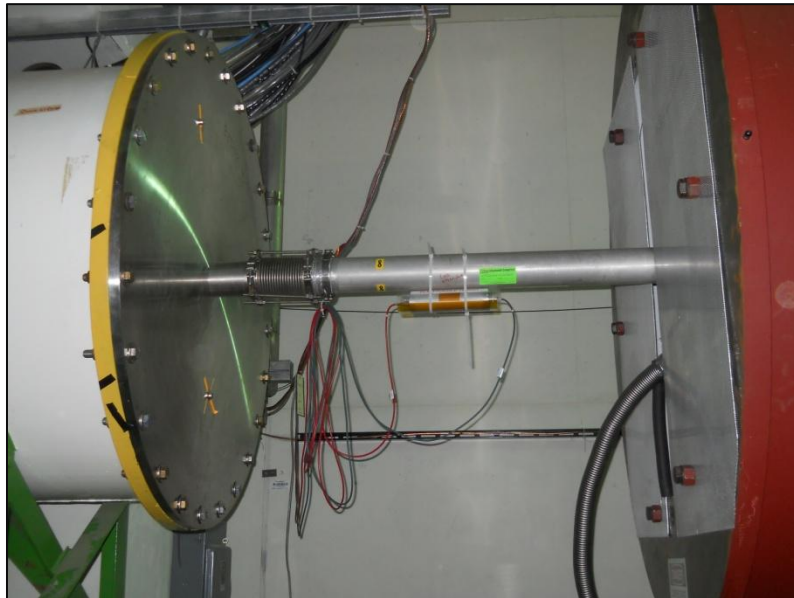

Figure 1 Upstream and downstream section of NM3. The 4 feet to 4 inch flange

The Setup

In order to make room for the Beam Cherenkov, we will install a vacuum bypass line just downstream of the large flange. However unlike those vacuum bypass lines in other similar enclosures of G2 and NM2, this bypass gap will have an attached pipe. Figure 2 is an example of one vacuum bypass with an attached pipe.
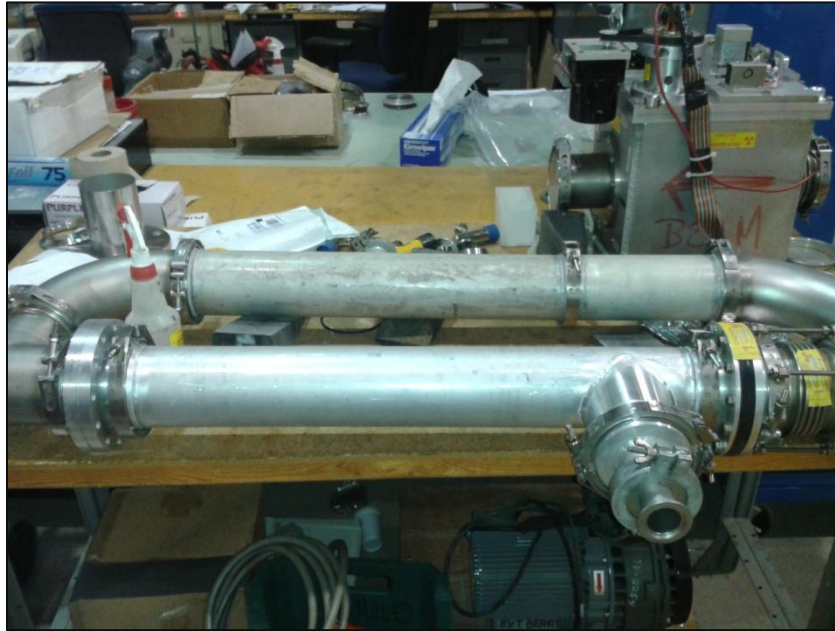

Figure 2 Bypass with Cherenkov pipe installed

The Beam Cherenkov

The Beam Cherenkov is a 27 and 3/8th inch long pipe with a diameter of four inches. Both ends of this pipe will have clamps identical to that of the surrounding Titanium windows, completing the vacuum separation. The pipe will be filled with 1 atmosphere of Helium. This pipe has three additional ports, one large port wedded at the bottom and downstream section to install the PMT can, and two smaller ports on the side to connect a gas flow system.

An Internal component of the Cherenkov will be a plate glass mirror angled at 45 degrees to the beamline. This mirror will be attached to the PMT can and installed as one unit. Once in place it can be bolted together. Once this can is connected the gas flow system will be able to properly flow Helium to its proper pressure. Figure 3 is the proposed Bean Cherenkov pipe drawing.
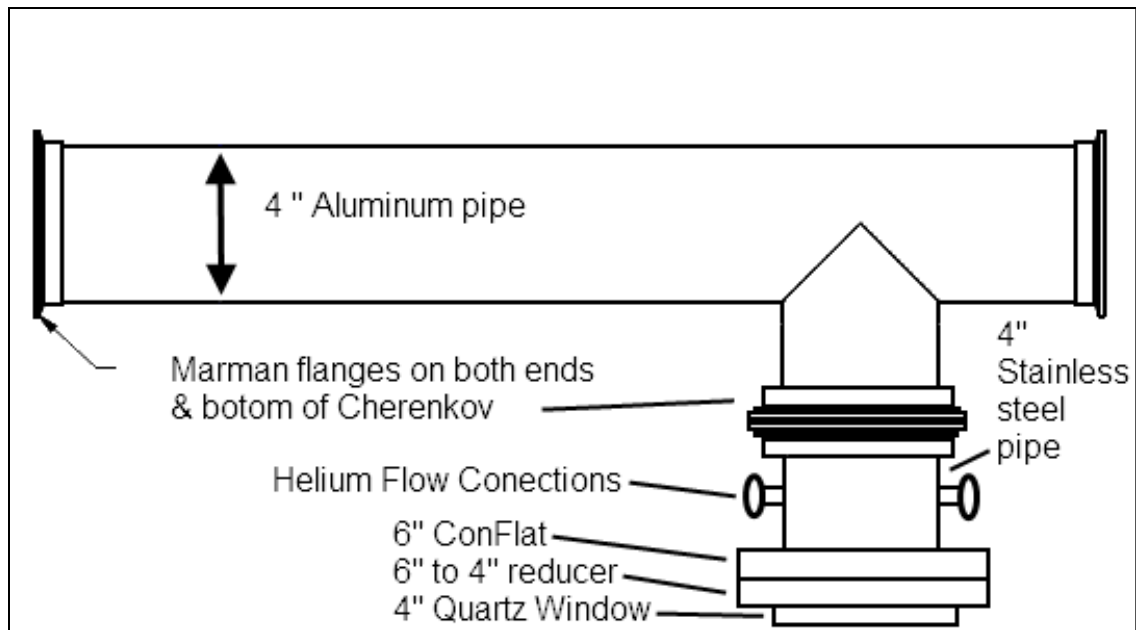
Figure 3 Proposed Beam Cherenkov pipe

Activation of Cherenkov

With this instrumentation device, we will be creating a known loss point at this particular location in the beamline. The amount and types of materials described earlier, Table 1 shows that the true interaction length of this device is 1.1% of an interaction length, for the worst case scenario using a plate glass mirror.

Helium Pipe with Titanium Windows & Mirror		Helium	Ti	Ti	Plate Glass	
density (g cm-3)	ρ	1.66E-04	4.54	4.54	2.40	Total
thickness (inches)	l	30.375	0.003	0.003	0.167	
thickness (cm)	l	76.2	0.00762	0.00762	0.424	
Nuclear interaction length (gm cm^{-2})	λ_I	71.0	126.2	126.2	99.6	
Interaction Lengths = Thickness/(λ_I/ρ)		0.018%	0.027%	0.027%	1.021%	1.094%

Table 1 Calculation of combined interaction length of helium Mylar mirror and titanium windows

A very conservative, order of magnitude estimate of the resulting dose rate at saturation, (after one day of shutdown, assuming all decays produce 1 MeV gammas) indicated about 31 mrem/hr at one meter from the center of the glass plate inside of the assembly. At one foot the corresponding dose rate could be as high as 327 mrem/hr.[1]

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[1] Private communication Kamran Vaziri

Transversally in NM3, the current shielding has 21.2 effective feet of dirt, or e.f.d. and longitudinally there are 21.3. For a category 4B in the shielding assessment, beam loss on a pipe, the required amount of e.f.d. is 10.0. Both transversally and longitudinally there is an adequate amount of shielding for a loss on a pipe.

	Cossairt Category	Current Shielding (e.f.d.)	Accident Required (e.f.d.)	Difference (ft)
Transverse	4B	21.2	10.0	11.2
Longitudinally	4B	21.3	10.0	11.3

Table 2 Shielding requirements for NM3, and adequate shielding

Since this Cherenkov will be in the path of the beam under normal operating conditions an additional required shielding amount is calculated. Equation 1 calculates the additional e.f.d. This amount is scaled from the dose rate limits of the category 4B. Table 2 summarizes this.

$$\text{Thickness} = -3.38 \log(100/500) = 2.36 \text{ e.f.d}$$

Equation 1 Additional shielding for normal running conditions

	Cossairt Category	Current Shielding (e.f.d.)	Normal Running Required (e.f.d.)	Difference (ft)
Transverse	4B	21.2	12.36	8.84
Longitudinally	4B	21.3	12.36	8.94

Table 3 Shielding requirements for NM3 Normal Running and adequate shielding

Summary

Experiment E-906 desires to measure bucket-by-bucket beam intensity using a helium Cerenkov counter. Fermilab Accelerator Division Mechanical Support has titanium windows in stock and available beam pipe in old enclosures that are easy to assemble in NM3 to make this bypass section. With the responsibility to fabricate the Cherenkov's internal components with PPD, this additional instrumentation will be beneficial to the experiment.